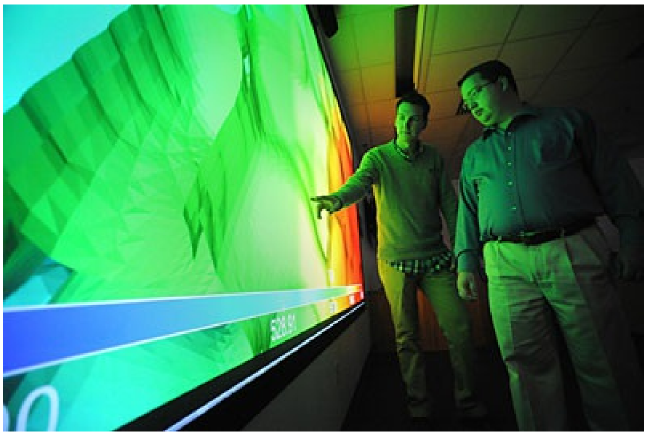
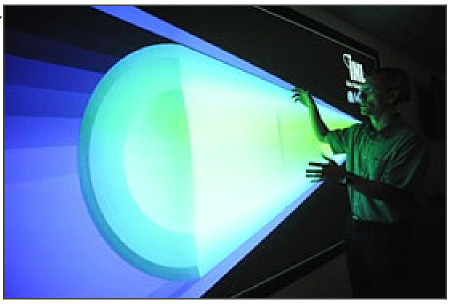


MOOSE (Multiphysics Object Oriented Simulation Environment) now makes modeling and simulation more accessible to a broad array of scientists and enables simulation tools to be developed in a fraction of the time previously required.

MOOSE simulation environment fosters a herd of modeling applications

By Nicole Stricker, *INL Communications & Governmental Affairs*

Modeling and simulation has now become standard practice in nearly every branch of science. Building a useful simulation capability has traditionally been a daunting task because it required a team of software developers working for years with scientists to describe a given phenomenon.



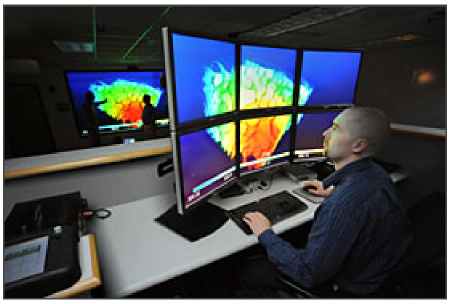
INL computational mathematician Jason Hales explains how the BISON code models nuclear fuel performance at the engineering scale.

Idaho National Laboratory's MOOSE (Multiphysics Object Oriented Simulation Environment) now makes modeling and simulation more accessible to a broad array of scientists. MOOSE enables simulation tools to be developed in a fraction of the time previously required. The tool has revolutionized predictive modeling, especially in the field of nuclear engineering — allowing nuclear fuels and materials scientists to develop numerous applications that predict the behavior of fuels and materials under operating and accident conditions.

Scientists who don't have in-depth knowledge of computer science can now develop an application that they can "plug and play" into the MOOSE simulation platform. In essence, MOOSE solves the mathematical equations embodied by the model.

Such a tool means scientists seeking a new simulation capability don't need to recruit a team of computational experts versed in, for example, parallel code development. Researchers can focus their efforts on the mathematical models for their field, and MOOSE does the rest. The simplicity has bred a herd of modeling applications describing phenomena in nuclear physics (BISON, MARMOT), geology (FALCON), chemistry (RAT) and engineering (RAVEN, Pronghorn).

The herd members are in various stages of development ranging from recently obtaining preliminary results to being nationally recognized as state-of-the-art. MOOSE and its herd of applications are currently licensed for use by 28 domestic and foreign laboratories, universities and companies — a user community that's growing monthly. This success illustrates how exceptional expertise and strategic partnerships converge at INL, the nation's nuclear energy laboratory.



Jason Miller, part of the team that developed MOOSE, runs the MARMOT code, which models microscopic changes in nuclear fuel during irradiation.

Listed here are some examples of how MOOSE and the herd are addressing numerous research questions (Capitalization practices vary by application, and all-caps does not necessarily imply an acronym).

BISON, MARMOT: BISON (led by Richard Williamson) is a thermo-mechanical code that models nuclear fuel performance at the engineering scale. MARMOT (led by Michael Tonks) models microscopic fuel changes during irradiation. MOOSE can couple the two applications to create a powerful multiscale, parallel, 2D and 3D fuel simulation capability that is truly predictive. This capability was demonstrated by simulating the behavior of a highly resolved full-length discrete-pellet fuel rod. The capability also was used to study the effects of a manufacturing fuel defect known as a "Missing Pellet Surface" — the first time such behavior has been analyzed in 3D over the full life of a fuel rod.

FALCON: Enhanced Geothermal Systems require detailed understanding of subsurface processes, primarily rock permeability. The FALCON computer modeling code (developed by Robert Podgorney and Hai Huang) enables researchers to simulate the physics of these processes with fine resolution while also modeling an entire geothermal reservoir. FALCON is currently licensed to research entities in the U.S., Australia and New Zealand.

PEREGRINE: This offshoot of BISON was designed specifically to model light water reactor fuel performance. It incorporates proprietary

Electric Power Research Institute (EPRI) models and supports the Department of Energy's Consortium for Advanced Simulation of Light Water Reactors (CASL) Innovation Hub. It was developed in collaboration with EPRI, Anatech Corp. and CASL.

RAT: The ReActive Transport code (developed by Luanjing Guo and Hai Huang) can be used to study carbon dioxide sequestration or environmental remediation of chemical spills. It solves reactive transport problems in the earth's subsurface to describe physical processes of fluid flow, solute transport, biogeochemical reactions and media-solution interactions.

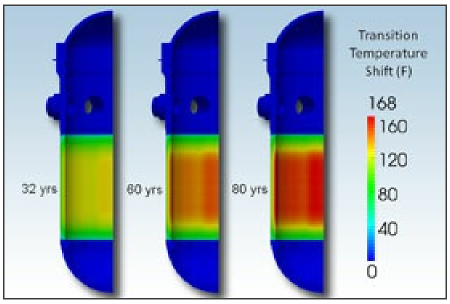
Did you know?

Derek Gaston, who led development of MOOSE, recently received national recognition. The INL computational mathematician was one of 96 recipients of the 2012 Presidential Early Career Award for Scientists and Engineers — the highest honor the U.S. government bestows on early career science and engineering professionals. Gaston leads the Computational Frameworks Group for INL's Fuels Modeling and Simulation Department.

RattleS$_N$ake: This radiation "SN transport" application (led by Yaqi Wang) could be used to design and study new nuclear fuels with enhanced accident tolerance. The code models the behavior of neutrons in nuclear fuel and reactor cores, including INL's Advanced Test Reactor. A better understanding of this neutron transport physics can sharpen understanding of factors that impact energy generation and material damage.

Bighorn: The physics contained in Bighorn (led by Richard Martineau) will simulate the mass and energy transport of reactor systems coolant. The project will help advance INL's Advanced Test Reactor (ATR) modeling and simulation to the forefront of computational methods for nuclear reactor design/analysis. Its applications could include light water reactors, Next Generation Nuclear Plant concepts and sodium-cooled fast reactors.

Condor: This module (led by Argonne National Laboratory) is a proposed high-temperature superconductivity simulation tool. The Argonne SciDAC (Scientific Discovery through Advanced Computing) effort will build Condor using the MOOSE framework. MOOSE, with its multiphysics coupling capabilities, adaptive mesh refinement and mesh generator interface — and proven scalability properties — is an ideal platform for this pressing computational science problem.



The Grizzly code models degradation that can build up after years of use in reactor pressure vessels and other components.

Grizzly: The code (developed by Ben Spencer) models degradation that can build up after years of use in reactor pressure vessels and other components. The code is being developed jointly with Oak Ridge National Lab and EPRI. Data from Grizzly could help nuclear power plant owners understand the sources of change in safety margins and inform decisions on component replacement and repair.

RAVEN: The RAVEN software tool (led by Cristian Rabiti) will provide a user interface for RELAP-7, the newest version of INL's Reactor Excursion and Leak Analysis Program, INL's premier reactor safety and systems analysis tool. The RAVEN software tool also will use RELAP-7 to perform Risk-Informed Safety Margin Characterization.

Pronghorn: This application, which rapidly approximates simplified physics, was originally developed for simulation of the gas-cooled pebble-bed Very High Temperature Reactor concept. It has now been used to conduct simulations of thermal fluids and neutronics for both pebble-bed and prismatic gas-cooled reactors and light water reactors.

(Posted May 2, 2013)

Feature Archive